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Meal Patterning in the Lactating Rat

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STRUBBE, J. H. AND J. GORISSEN. *Meal patterning in the lactating rat*. *PHYSIOL. BEHAV.* 25(5) 775-777, 1980.—The present study was undertaken to investigate feeding behaviour of the lactating rat over the day-night cycle. Food intake was recorded continuously in six pregnant and subsequently lactating female rats with 10 pups each. Although there was a twofold increase of food intake during the first post partum week, the meal frequency did not increase above the level of previous weeks. Only the mean meal size increased. After this week food intake increased to three times the normal intake, meal size did not change but meal frequency increased in favour of daytime meals. It is suggested that with moderate caloric demands food intake regulation in the rat occurs through changes in meal size. With higher energy requirements, however, meal frequency is also affected. The possible causal factors involved in the change in feeding are discussed.

Lactation Meal pattern Food intake regulation Circadian rhythm

FOOD intake by animals depends on several internal and external variables. It is known that animals can adapt to changes in caloric content of the diet, so that over a wide range of contents intake matches energy expenditure and body weight remains essentially unchanged. On a diet with constant caloric content an increase of energy expenditure in rats results in increased food intake. Examples of this phenomenon are the hyperphagia resulting from a decrease of environmental temperature [3], the diabetic state [8], and lactation [2, 4, 5, 6].

Increases of daily food intake may be effected by an increase in the frequency of meals, the individual size of meals or both. After temperature decrease [3], in the diabetic state [8], and in the lactating rats with a small litter [2,5] the size of meals was increased whereas frequency was unchanged. These studies show that with moderate changes in energy expenditure, food intake regulation in the rat occurs by changing meal size. In terms of food intake regulation it is of interest to see how feeding behavior changes with higher energy requirements. This was investigated by measuring the meal patterns of the lactating rat with a larger litter size.

METHOD

Six female Wistar rats were housed in individual perspex cages (25×25×30 cm) on wood shavings at a room temperature of 20°C. Lights were on from 05.00 to 17.00 hours. The intake of food during the whole day-night cycle was registered by movements of a bar situated just in front of a food hopper (13 cm above the shavings). These hoppers were regularly filled with food pellets (Muracon, Trouw, The Netherlands). When the animals were eating the bar was activated. Spillage was collected in an undertray attached to the hopper.

The rats were accustomed to this experimental situation over two weeks. Litter size varied between 11-14 pups, but

this was standardized to 10 pups per litter. After 3 weeks the young animals were removed, and the meal pattern of the mother rat was recorded for another two weeks.

It has been reported that the ideal criterion for defining the inter-meal interval lies between 10 and 40 min for a rat eating in the ad lib condition [2]. Taking this into account, we arbitrarily adopted an inter-meal interval of 15 min, a method that produced a clear meal pattern. There was no change in meal frequency when inter-meal interval criteria between 10 and 20 min were chosen. Single bar presses lasting 1 min or less were not taken into account as visual observations proved that these were artifacts caused by exploratory behavior. The height of the hopper prevented the pups from eating the diet.

Food was weighed daily. We found a highly significant correlation between duration and size of individual as well as series of meals, by measuring food intake directly ($p < 0.01$; $\tau = 0.9$ Kendall's rank correlation).

RESULTS

Body Weight and Food Intake (Fig. 1)

Over the estrous cycle food intake varied between 17.3 ± 0.8 g in diestrus and 13.0 ± 1.1 g in estrus. On the second day after coitus food intake was established at diestrous levels and remained high for two weeks. Body weight increased gradually during this period. During the last post coitus week food intake increased 20%, while body weight increased about 60 g. At birth the mothers lost body weight. From this day onward, food intake increased rapidly, reaching a mean of 58.3 ± 0.7 g during the third week postpartum. Body weight also increased during the lactation period.

The first day after weaning food intake of the mothers was still high but thereafter returned to prepartum levels. Body

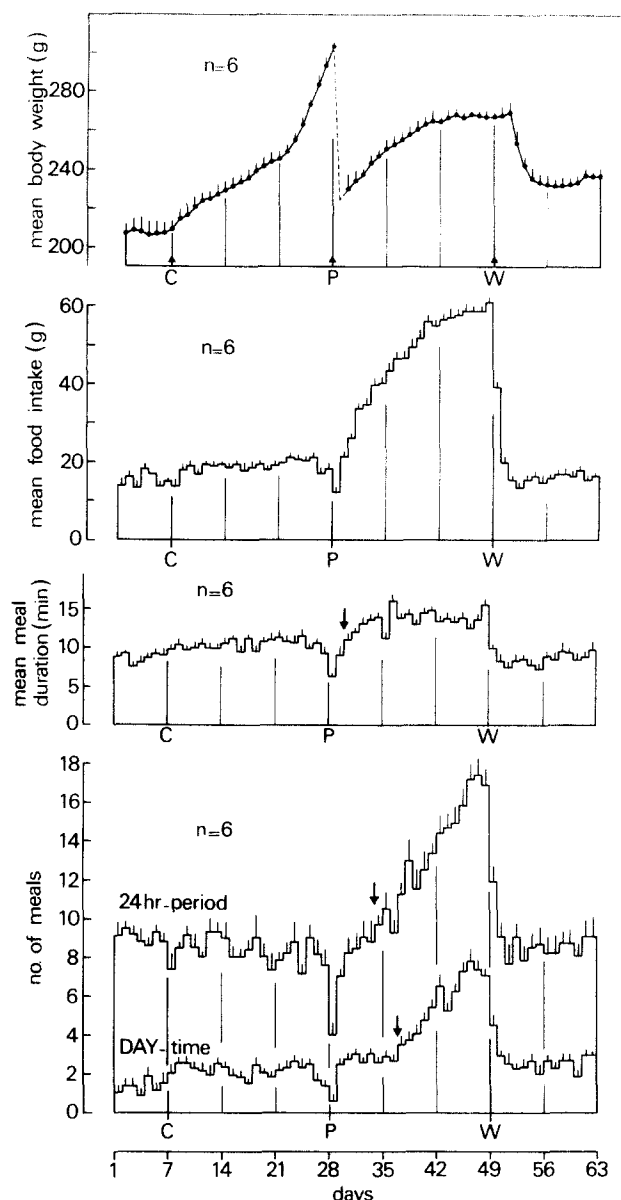


FIG. 1. Mean body weight (g), food intake (g), meal duration and frequency (SEM) per day of 6 rats in respectively a control week, three weeks post coitus (C=coitus), three weeks post partum (P=partus) and two weeks after weaning (W). Arrows indicate changes in food intake strategy.

weight decreased gradually to a constant level about 20 g higher than the precoitus level.

Meal Pattern, Frequency and Duration During 24 Hr

During the precoitus week, feeding activity was nocturnal and about 90% of the total daily intake was eaten in the dark phase. In the night-time, feeding showed a typical bimodal pattern (Fig. 2). A high level of feeding activity in the first and the last two hours of the night was prominent. This pattern persisted over the three post coitus weeks and in the first week of the post partum period. In the following post partum weeks food intake in the night increased but the typi-

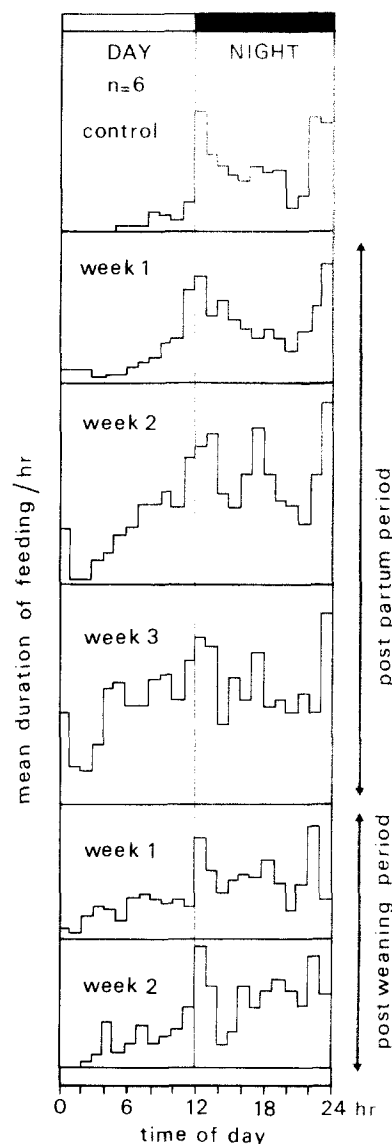


FIG. 2. Patterning of food intake per week of 6 rats expressed as the mean duration of feeding per hour, respectively, a control week, three weeks of lactation and two weeks after weaning.

cal feeding pattern persisted. During the post partum period more food was eaten in the light phase. In weeks 2 and 3 this occurred by an increase of feeding activity earlier in the day. This continued until the mean night-time level was reached in week 3 post partum. After weaning this pattern persisted although the general level decreased. During the second week, there developed a gradual return to the normal distribution of daytime feeding.

The mean meal frequency over the whole day did not change significantly during the post coitus weeks, whereas a small increase of mean meal duration was observed (Fig. 1). Food intake increased from 20 to 40 g during the first post partum week. This increase was accomplished through an increase in meal size but not in meal frequency. In contrast the increase in food intake during the second and third post partum weeks occurred through an increase in meal fre-

quency but not in meal size (Fig. 1). In particular, an increase in day-time meals was prominent.

DISCUSSION

Several reports mention a two-fold increase of normal food intake during lactation [2,6]. Others, however, show a three-fold increase [4,5]. It has been shown that this depends on the litter size [5].

The present study shows a two-fold increase of food intake during the first week post partum. Thereafter food intake increased to three times that of non-lactating controls. The increase of meal duration (i.e., meal size) confirms other reports [2, 5, 6].

When food intake increased to more than twice the normal amount an increase of number was also observed. This was mainly due to a sudden increase in the number of day-time meals. Although an increased meal frequency with a large litter was observed in a previous study [5], this sudden change in feeding at Day 10 post partum was not observed before.

As regards physiological causation of the extra food intake during lactation several possibilities deserve consideration. It is clear that the increased food intake is a result of the high energy requirements associated with the process of milk synthesis. When this is increased by means of increasing the litter size, food intake of the dam also increases [5,6]. There is evidence that the suckling stimulus itself might play a role in the causation of the higher meal frequency apart from regulation by signalling energy expenditure [4]. However, these results are equivocal. If the suckling stimulus is an important factor one would expect an increased meal frequency from the beginning of the lactation period. Since in our study meal frequency increased suddenly only after the first week of lactation at a moment that meal size reached its maximum, it is more likely that the suckling stimulus itself plays a minor role in determining meal frequency. Factors signalling the rate of energy expenditure are probably more important.

After weaning, food intake decreased to normal levels. However, during the first day post weaning the rats continued to eat at high levels. This was probably due to a continuation of milk synthesis even when the suckling stimulus was absent [5]. Meal patterning during adjustment to an increased rate of energy expenditure or deficit were measured in diabetic rats [8], in rats under low temperature condition [3], and after fasting [7]. These studies show similar effects with the results of this study, in that with moderate increased energy expenditure regulation of food intake occurs through changing meal size without affecting timing. Even diabetic rats with a totally disrupted metabolism showed the same meal frequency as their controls [8].

There is evidence that the feeding pattern is under strong control of a circadian oscillator [9]. This pattern can be disrupted by lesioning of the nucleus suprachiasmaticus [9] and by VMH lesioning [1,8]. In the latter daily food intake increased in the dynamic phase only twice of the normal control. The pattern persisted even when normal amounts of food were ingested in the static phase [1]. This indicates that in the VMH lesioned rat pathways associated with the circadian control of feeding are disrupted.

A bimodal pattern was still present during the third post partum week, although feeding activity was almost equal in day and night. This suggests intact circadian control.

The increased meal frequency during day-time, in the second and third post partum weeks, shows that under extreme high rates of energy expenditure the rats are capable of changing their diurnal feeding pattern. The physiological mechanisms underlying this causation are not known but certainly internal factors signalling the high rate of energy expenditure are responsible.

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